AN ECOLOGICAL STUDY OF CROCODILES IN RUHUNA NATIONAL PARK, SRI LANKA[1]

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(*With three text-figures*)

Key words: Marsh crocodile, *Crocodylus palustris*, estuarine crocodile, *C. porosus*, Ruhuna National Park, basking, feeding, conservation

A study was carried out in Block I (140 sq. km) of the Ruhuna National Park (RNP) opportunistically from October 1991 to October 1994, in order to study the two species of crocodiles occurring in Sri Lanka, viz. *Crocodylus palustris* and *C. porosus*. A total of 341 sightings of the two species were made on 77 occasions, 307 sightings on *C. palustris* and 34 sightings on *C. porosus*. Among *C. palustris*, solitary animals made up most of the observations (55.8%) while pairs accounted for 13.0%. Of the 22 water-holes that were surveyed, 13 (59%) had only one crocodile. Although both species could be seen at any time of the day, the number basking increased with the increase in the ambient temperature, and peaked around noon. *C. porosus* basked alone, and *C. palustris* communally. The population structure consisted of 44% hatchlings, 6% juveniles, 24% subadults and 26% adults. Only adults of *C. porosus* were observed. Hatchling losses can be very high through predation by birds and mammals. Both species feed on a variety of food, ranging in size from aquatic insects and crustacea (in hatchlings) to fish, frogs, birds and large mammals (in adults). The minimum crude density values for *C. palustris* and *C. porosus* are estimated to be 0.72 and 0.07 animals per sq. km respectively. The populations of both species in Block I appear to be secure and viable.

INTRODUCTION

Of the 13 species of 'true' crocodiles (Subfamily: Crocodylinae) that are extant in the world, 8 species occur in Asia, of which 2 are found in Sri Lanka, namely the freshwater, or marsh crocodile, or mugger (*Crocodylus palustris*) and the saltwater or estuarine crocodile (*C. porosus*). While *C. palustris* is listed as 'vulnerable' by IUCN (Groombridge, 1993), *C. porosus* has been transferred to the 'low risk' category, given the tens of thousands known to be present in numerous localities across its geographical range. However, in Sri Lanka, given its low number and restricted distribution, *C. porosus* is more threatened than *C. palustris*. According to Whitaker and Whitaker (1989), "Sri Lanka has more mugger crocodiles than the rest of the subcontinent put together, mostly concentrated in the two national parks, Yala (=RNP) and Wilpattu." Even though this may not be strictly true now, it indicates the high number of mugger crocodiles still occurring in Sri Lanka. Both species found in Sri Lanka are listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Crocodiles were once plentiful in Sri Lanka. The man-made reservoirs or tanks in the Dry Zone were teeming with crocodiles (Baker

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1853; Tennent 1859; Hennessey 1949). But today, both species have declined in range and number as a result of poaching and loss of habitat. Crocodiles are almost confined to the first peneplain in Sri Lanka. They represent an excellent renewable natural resource and, therefore, their conservation can be made much easier if such a resource is used for the benefit of the people who share the land with them (Child, 1987). Unfortunately, crocodiles have a poor image in Sri Lanka. They are considered dangerous, and few would really regret their disappearance. The general public is unaware of the beneficial role played by crocodiles in wetlands. Legislation alone cannot save a species if the public is against its conservation. As Sale (1985) points out, a sound scientific understanding of a natural resource is fundamental to the management of that resource. Nowhere is this more true than in Sri Lanka, where the aims of crocodile management are straightforward preservation of the species within protected areas, with no interest in utilization despite the high economic value of the skin. So far, there has been no ecological study of crocodiles in Sri Lanka. Deraniyagala (1953) provides detailed information on the taxonomy, range and ecology of the two species of crocodile in Sri Lanka, while Whitaker and Whitaker (1979) carried out the first comprehensive survey of crocodiles in Sri Lanka. More recently, Porej (1997) studied the distribution of the two species along the south-western coast of Sri Lanka. An island-wide reassessment of their status was carried out by Santiapillai & de Silva (1998, under review).

Study Area

The study was carried out in Block I of the Ruhuna National Park, in southeast Sri Lanka in the low country Dry Zone (Fig.1). Block I is about 140 sq. km in extent, and is separated from the rest of the park by the Menik Ganga (= river) in the northeast. The vegetation of the park has been classified by Mueller-Dombois (1972) into three physiognomic categories: (a) forest (with at least 20% of crown biomass above 5m in height), (b) scrub (less than 20% of crown biomass above 5m), and (c) grassland or plains. The dominant forest trees are *Manilkara hexandra* (palu), *Drypetes sepiaria* (weera) in well drained soil, and *Limonia acidissima* (divul) and *Salvadora persica* (malithan) in poorly drained areas (Balasubramaniam *et al.*, 1980). The coastal region in Block I has numerous water-holes of varying size and salinity, surrounded by grasslands where the main species are *Eragrostis viscosa*, *Dactylotaenium aegyptium*, *Sporobolus diandrus*, *Echinochloa colonum*, *Setaria pallidifusca* and *Alloteropsis cimicina* (Balasubramaniam *et al.*, 1980). The fauna includes threatened species such as the Asian elephant *Elephas maximus* (E), leopard *Panthera pardus* (T), sloth bear *Ursus ursinus* (I), and water buffalo *Bubalus bubalis* (V). In addition, there are several herbivores: wild pig *Sus scrofa*, sambar *Cervus unicolor*, spotted deer *Axis axis* and mouse deer *Tragulus meminna*, which are potential prey species of the crocodiles. Other reptiles include the common monitor lizard *Varanus bengalensis*, cobra *Naja naja*, Russell's viper *Daboia russelli*. At least three species of sea turtles, the green *Chelonia mydas* (E), olive Ridley *Lepidochelys olivacea* (E) and leatherback *Dermochelys coriacea* (E), nest along the beach (Hewavisenthi, 1990). The most numerous crocodile in Ruhuna National Park is the marsh crocodile or mugger (*C. palustris*).

Methods

The study on crocodiles was incidental to a much larger study on the mammals of the Ruhuna National Park and was carried out in Block I opportunistically from October 1991 to October 1994. All observations were made from a vehicle, using a pair of 7 x 52 binoculars, from

Fig. 1: Map of Block I of Ruhuna National Park showing the waterholes

0600 to 1900 hr, during which time most of the water-holes in the park were visited. At every sighting of crocodiles, their number, location, habitat and behaviour were noted. Whenever possible, the species was identified based on field criteria such as the shape of the dorsal osteoderms — subquadrangular plates transversely sutured to one another in *C. palustris*, and ovoid and separated by skin in *C. porosus* (Deraniyagala, 1953). But this was not easy, for as Daniel (1983) points out, the two species are difficult to distinguish in the field. When the two species

are in water, they are almost impossible to tell apart. Besides, smaller individuals are difficult to distinguish in the field. Wherever possible, the length of the animals was estimated visually. Four categories were recognized: hatchlings (<0.5 m), juveniles (0.5-1.0 m), subadults (1.1-2.0 m), and adults (>2 m). The crocodiles were also monitored from 0600 to 1900 hrs at Buttuwa Wewa during the peak of the dry season in early October 1991, just prior to the northeast monsoon rains, to study their basking behaviour. An attempt was made to estimate the minimum number and density of crocodiles by taking into account the maximum number recorded from each waterhole within a sampling session (7-10 days).

Results

A total of 341 crocodiles (of both species) were recorded in 77 observations, of which 307 sightings were on *C. palustris* and 34 on *C. porosus*. Among *C. porosus*, solitary animals made up 55.8%, while pairs accounted for 13.0% (Fig. 2). The largest group seen during the survey consisted of 44 animals (39, *C. palustris* and 5, *C. porosus*), in the Buttuwa reservoir. It is likely that many of the pairs observed in Buttuwa reservoir are adult male and female marsh crocodiles. Of the 22 water-holes that were surveyed, 13 (59%) had only one crocodile (*C. palustris*) each. Crocodiles were observed to move from one waterhole to another during the dry season. As the dry season progresses from May to September, many of the smaller water-holes become bone dry, and the crocodiles (*C. palustris*), move either to large water-holes such as the Buttuwa Wewa, Wilapala Wewa, Heen Wewa and Katagamuwa tank, or concentrate along the Menik Ganga. In the dry season, one crocodile (*C. palustris*) was observed more than a kilometre from the nearest water-hole in the neighbouring Block II. At the peak of the drought, marsh crocodile numbers along

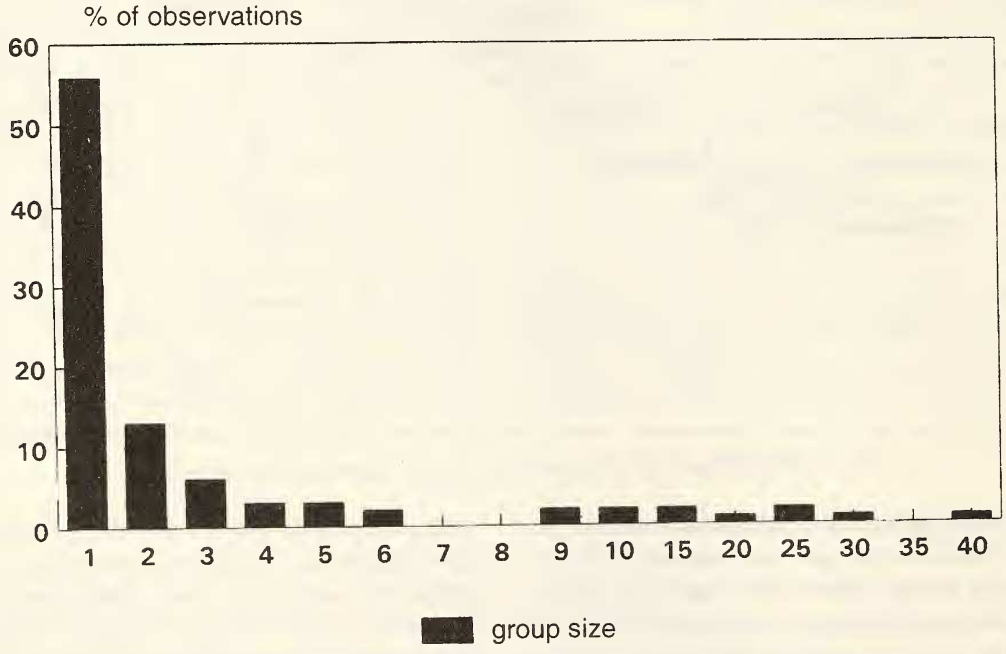

Fig. 2: Frequency of sighting of crocodile groupings of various sizes

the banks of Menik ganga can be as high as 35 animals per km. Furthermore, if the drought is prolonged, the Menik ganga mostly dries up, leaving scattered pools of water along the banks. These pools, which are no more than 0.5 m in depth, and a few sq. m in area, may be inhabited by up to 4 marsh crocodiles. The largest estuarine crocodile seen measured about 3.0 m at Diganwala, while the largest marsh crocodile was about 2.5 m at Gonalabba lagoon.

TABLE 1
SIZE AND COMPOSITION OF MARSH CROCODILES (*C. PALUSTRIS*) IN RNP (N = 50)

size class (m)	number	percentage	category
<0.5	22	44	hatchling
0.5-1.0	3	6	juvenile
1.0-2.0	12	24	subadult
>2.0	13	26	adult

When the maximum number observed in each waterhole within a sampling session (7-10 days) was taken into account, there were 101 marsh crocodiles and 10 estuarine crocodiles in Block I. This amounts to a minimum crude density of 0.72 per sq. km of *C. palustris*, and 0.07 per sq. km of *C. porosus* in Block I. Among *C. palustris*, 44% were hatchlings, 6% were juveniles, 24% subadults, while sexually mature animals made up 26% (Table 1). The observed *C. porosus* were all adults. However, the hatchlings and juveniles taken as *C. palustris* may have included some *C. porosus* as well, since these two species are difficult to distinguish in the field from a distance, especially when they are small. Crocodiles could not be sexed in the field.

Crocodiles were seen throughout much of the day, either in water, or basking on land. In Block I, both species were observed basking on the embankment of the reservoirs or on the banks of rivers and streams. The pattern of basking observed at Buttuwa Wewa was generally the same in both species (Fig. 3). The ambient temperature increased as the day progressed, and there was a substantial increase in the number

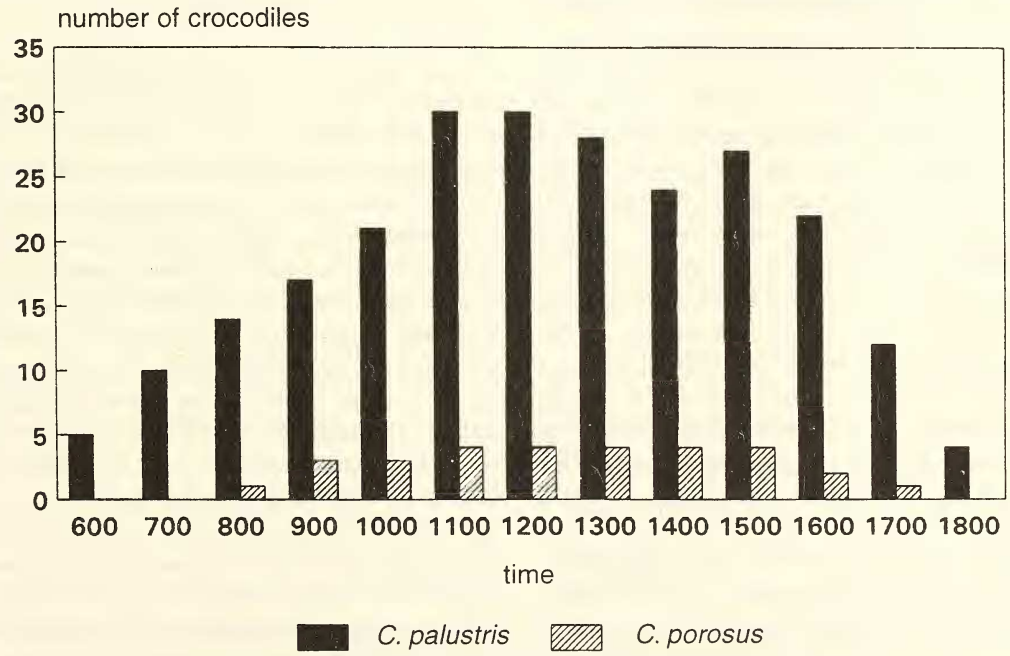

Fig. 3: Pattern of basking activity shown by both species of crocodile

of *C. palustris* observed basking, with the maximum number recorded from 1100 to 1200 hrs. A much smaller number of *C. porosus,* while showing a similar trend, were observed basking from 0800 hrs, reaching a peak from 1100 to 1500 hrs, and subsequently declining until 1700 hrs. Another behavioural difference that may help in the identification of species in the field concerns basking. Marsh crocodiles were seen basking communally, while estuarine crocodiles were never observed basking together. However, the estuarine crocodile was also seen basking in the company of marsh crocodiles. While basking, one *C. palustris* was observed defaecating, after which it moved its hind leg over the pile of faeces and shifted its hind parts a little away, then continued basking. Basking crocodiles varied in the length of time they kept their mouths open, the maximum period being 2 hrs.

Both species of crocodile were observed feeding on frogs, which are abundant in almost all the water-holes in Block I. In the dry season, frogs may form a substantial part of the crocodiles' diet at the smaller water-holes where there are no fish or crustaceans such as crabs or prawns, since the water-holes dry up. However, in the lagoons such as Gonalabba, Uraniya and larger water-holes at Heenwewa, Wilapala Wewa or Palatupana, into which *Tilapia* were introduced, crocodiles fed largely on such fish. Two marsh crocodiles were seen at night attacking a dead buffalo, in Uraniya plains. Marsh crocodiles were also observed feeding on the carcass of spotted deer, and sambar. In the present study, estuarine crocodiles were not observed feeding on carrion, although it is quite likely that they do. They were not observed doing so, though they were seen at night away from the water-holes. Marsh crocodiles were seen pulling the carcasses either from land or near the water's edge into water and eating them. Once the carcass is under water, it is out of reach of other scavengers such as jackal (*Canis aureus*) and wild pig (*Sus scrofa*). In Ruhuna National Park, crocodiles of both species catch most of their terrestrial prey near the edge of the water. Much of the feeding appears to take place at night.

Hatchling losses can be very high due to predation. In Block I, hatchlings were seen among the roots of *Rhizophora* trees in the mangroves at Buttuwa, where the prop-roots form a three dimensional mesh, which even some large wading birds find difficult to penetrate. The only birds large enough to attack hatchlings are the black-necked stork (*Ephippiorhynchus asiaticus*), lesser adjutant stork (*Leptoptilos javanicus*), spot-billed or grey pelican (*Pelecanus roseus*), and raptors such as crested hawk eagle (*Spizaetus cirrhatus*), crested serpent eagle (*Spilornis cheela*), brahminy kite (*Haliastur indus*) and white-bellied sea eagle (*Haliaeetus leucogaster*). According to Park officials, egg predation by jackal (*Canis aureus*), monitor lizard (*Varanus bengalensis*) and wild pig can be substantial.

Discussion

In addition to the crocodiles that were observed in Block I of RNP, another 150-200 marsh crocodiles were recorded from the Katagamuwa Wewa (Fauna International Trust, 1993; de Silva, pers. obs.), which lies just outside the northwest corner of Block I (Fig. 1). As these marsh crocodiles regularly move in and out of Block I, they could be considered a part of the crocodile population of Block I. If these crocodiles are also taken into account, then the minimum crude density of the marsh crocodile in Block I could be as high as 1.99-2.16 animals per sq. km. Marsh crocodiles live in groups, but male estuarine crocodiles, being aggressive and highly territorial, tend to live alone. Furthermore, in estuarine crocodiles, the large territorial males may service a number of females, and thus keep potential competitors at bay (Webb and Manolis, 1989). This may explain the movement of some

males far into the interior, away from the estuaries. The number of crocodiles inhabiting a particular waterhole depends not only on the productivity of the waterhole, but also on its size. Usually, large waterholes such as Wilapala Wewa and Buttuwa Wewa support relatively large numbers of crocodiles, in particular *C. palustris*, all year round.

In general, female crocodiles grow more slowly and reach maturity at a smaller size than males, which continue growing and usually exceed females in maximum size (Ross, 1998). According to Webb and Manolis (1989), in saltwater crocodiles, the females reach sexual maturity at the age of 12 years (2.3 m total length), while the males become sexually mature at the age of 16 years (3.4 m total length). But female marsh crocodiles of 6 years and 8 months of age (2.2 m) have also been known to reach sexual maturity in India (Whitaker and Whitaker, 1989).

As crocodiles cannot maintain a constant body temperature by physiological means, heating and cooling are of particular importance to them (Webb and Manolis, 1989). Crocodilians have a preferred body temperature of about 30-33°C, and to achieve this temperature range, they move to and fro between water and land. Basking crocodiles usually orient themselves in such a way as to get the maximum exposure to the sun. But as their body gets heated, they reduce the heat uptake by turning and facing the sun, and opening their mouth to cool the brain through evaporative cooling (Webb and Manolis, 1989). Crocodiles in general are very sluggish, and their short periods of activity are usually followed by long periods of inactivity. Wading birds were seen feeding quite close to the basking crocodiles.

Crocodiles are very effective aquatic predators. They are also opportunistic feeders, and catholic in their diet. Most wild crocodiles are known to be attracted to carrion (Webb and Manolis, 1989). In Katagamuwa tank, marsh crocodiles are known to feed communally on fish, when water is low (Fauna International Trust, 1993). Although game animals fall prey to crocodiles, such predation is unlikely to have a significant effect on their numbers. It is likely that the bulk of the crocodiles' food in the park consists of fish, frogs and water birds, which are most abundant the year round. As the dry season progresses, many of the water-holes dry up. Fish become concentrated in a few water-holes, which attract crocodiles from other areas. Crocodiles can go for months without feeding (Whitaker and Whitaker, 1989). They are known to feed on a variety of food items that range in size from freshwater mussels to water buffalo (Webb and Manolis, 1989). Their food changes with their size: beginning with aquatic insects, crustacea, small fish, and as they grow larger, vertebrates such as fish, turtles, birds and mammals (Ross, 1998). Much of the feeding appears nocturnal, for which they are well equipped with good eye sight. The retinal tapetum situated at the back of the eyeball is an image intensifier, allowing crocodiles to see better even in low light intensities (Webb and Manolis, 1989).

The predators on crocodile hatchlings, apart from those observed in Block I, include larger crocodiles, freshwater turtles, large predatory fish and python (Webb & Manolis, 1989). Although crocodiles lay many eggs, only 1 % of the hatchlings may survive to maturity, largely due to predation. The estuarine crocodile also suffers heavy losses when flash floods inundate estuaries where its mound nests are found.

Given the high number of crocodiles, especially marsh crocodiles, present in Block I of RNP, and the fact that these animals maintain genetic exchange with crocodiles from the rest of the Park, it is clear that both species of crocodile present in Block I constitute secure and viable populations. Factors such as desiccation of eggs during severe drought and avian predation on hatchlings appear to help regulate crocodile numbers in the Park.

Conservation and Management

There has never been any conservation programme designed specifically for crocodiles in Sri Lanka. While, they are being killed as vermin or poached for meat and skin outside the protected areas, their prospects for long-term survival appear good in a few protected areas such as the Ruhuna National Park in the southeast and the Wilpattu National Park in the northwest. The policy of allowing nature to follow its own course appears to have benefited crocodiles within these protected areas. Crocodiles being large predators, require very large areas of undisturbed wetlands to survive (Ross, 1998). Such areas are becoming increasingly difficult to find in Sri Lanka, as a result of the increase of its human population, currently estimated to be over 18 million. Therefore, protected areas appear to be the last refuge for wildlife. There have been no recent reports of crocodiles being poached within the Park, although several were killed outside.

The approach to management of crocodiles in the park is therefore a conservative one, in that the crocodile habitats are secure and remote from centres of high human population. So far, management measures have boosted the numbers of the crocodiles inside RNP. The crocodile, being an exceptionally adaptable predator, is able to survive on a broad spectrum of prey species. So the emphasis in crocodile conservation policy must be on maintaining a variety of prey, and preventing the pollution and destruction of the Park's wetlands. The national parks, however, remote from human population centres, are still prone to environmental disturbances outside their boundaries.

The crocodile is well adapted to respond to a "sanctuary strategy". There are good grounds to believe that it will increase in number under protection, which is by far easier, cheaper and more likely to be successful, than re-introduction. Local people strongly object to the translocation of a potentially dangerous predator such as the crocodile, to their neighbourhood. Law enforcement will become ineffective in the face of public hostility to crocodiles. The dissemination of factual information on crocodiles and their role in the ecosystem may help change the people's attitude.

In the final analysis, the survival of crocodiles is intimately linked with their acceptance by local people and the attitude of their politicians. What is needed is the widest possible acceptance of crocodiles as a renewable natural resource. Their conservation can be made easier, if this resource is used for the benefit of the people who share the land with them (Child, 1987). If crocodiles are properly managed, either in farms or as wild populations, they can become a considerable economic asset to the countries that contain them (Bellairs, 1987).

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